LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA14 | Newton Purcell to Brackley

Great Ouse at Turweston modelling report (WR-004-005)

Water resources

November 2013

ES 3.5.2.14.15

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Department for Transport

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Volume 5: Appendix WR-004-005

Turweston Viaduct Flood Risk Report

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1 Executive summary

1.1.1 This report describes the flood risk assessment undertaken for the Turweston viaduct at the River Great Ouse crossing.

1.1.2 A flow for the River Great Ouse was calculated using the Flood Estimation Handbook (FEH) Revitalised Flood Hydrograph (ReFH) approach.

1.1.3 A one-dimensional (ISIS) hydraulic model was constructed using cross sections taken for the HS2 light detection and ranging (LiDAR) data.

1.1.4 20 year, 100yr event with a 20% allowance for climate change and 1000 year flood events were simulated.

1.1.5 Various scenarios were tested which progressively reduced the viaduct length to assess the impact of narrowing the crossing by bringing the rail embankment onto the floodplain.

1.1.6 A 50m long viaduct was found to have a negligible impact on flood risk in this area.

2 Introduction

2.1.1 This document presents an assessment of the fluvial flood risk of the River Great Ouse, for the Proposed Scheme north of the village of Turweston, near Brackley.

2.1.2 The Proposed Scheme crosses the Great Ouse on a viaduct, some 460m north of Turweston Mill, and 400m to the east of Versions Farm.

2.1.3 The predicted flood extents and peak water levels are reported here, as defined by hydraulic modelling.

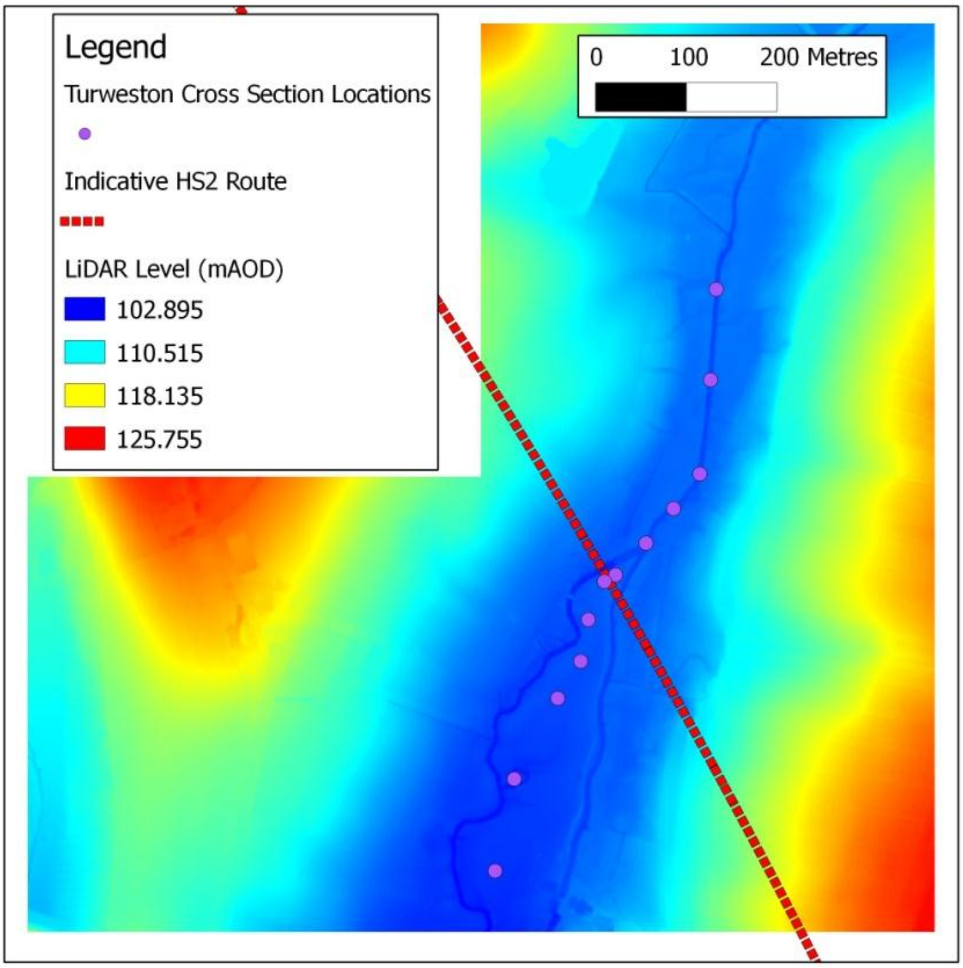
3 Baseline scenario

3.1 Location plan and topography

3.1.1 The study catchment is within the rural upper reaches of the River Great Ouse near Turweston, Brackley. The study area covers short reach of the river as shown by the aerial survey plan in Figure 1. This figure presents a detailed view of the topography generated using LiDAR data. The natural valley and floodplain are clearly defined, with the artificial channel to the mill pond (the mill stream), passing along high land to the east of the floodplain.

3.1.2 The channel bifurcates at the point of the crossing, with a control structure in place to regulate the split of flows between the two channels.

Figure 1: HS2 Topography (0.2m2 Resolution LiDAR)



3.2 Hydrology study

3.2.1 The River Great Ouse was evaluated using the Flood Estimation Handbook CDROM. It has a catchment size of $38km^2$ at the proposed crossing and a relatively shallow gradient. It has an average drainage path length of 7.37km. It has a low urban portion and can be considered essentially rural.

3.2.2 The climate and soils descriptors show that the catchment is relatively dry, with low annual rainfall (SAAR = 678) and a low proportion of time annually where soils are "wet" (PROPWET=0.30). There is some recorded attenuation due to reservoirs or lakes within the catchment (FARL=0.966).

3.2.3 A flow for the Great Ouse was calculated using the ReFH approach applied for the whole catchment upstream of the mill stream bifurcation.

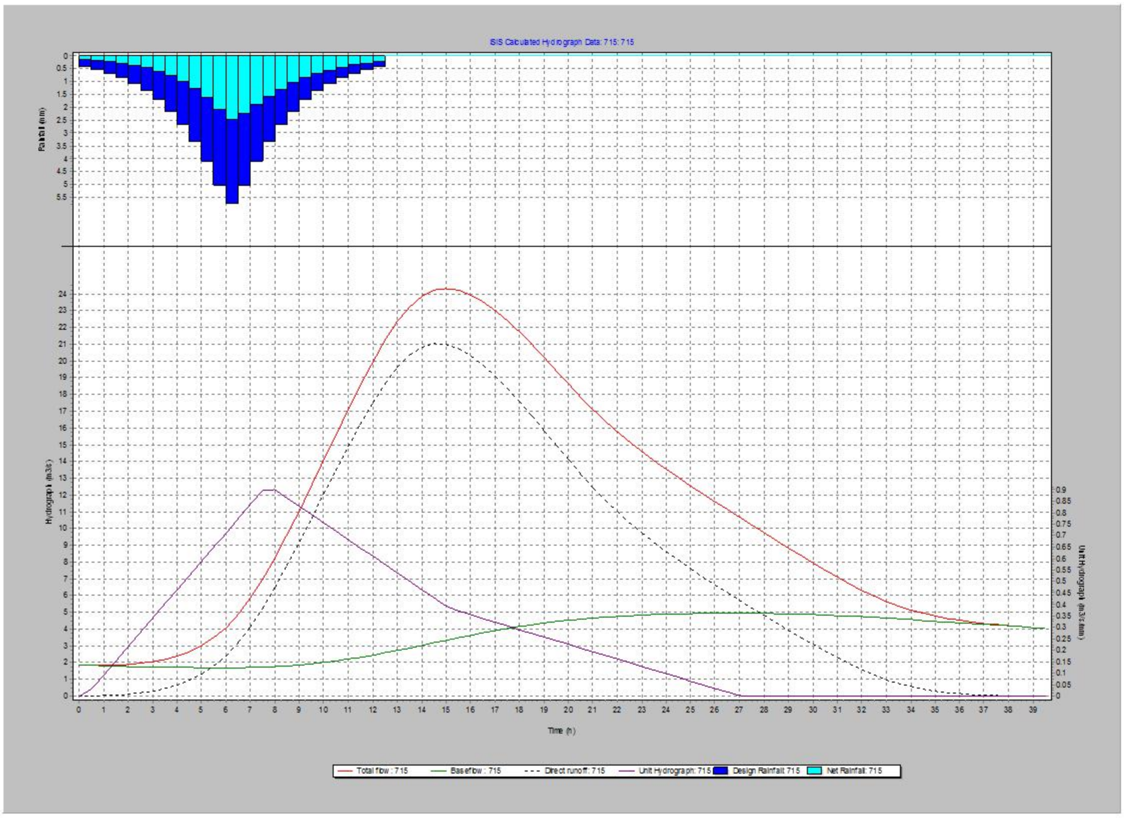
3.2.4 A 20% allowance was made for climate change was applied to the 100 year design event.

3.2.5 The ReFH hydrographs generated for the Proposed Scheme assessment were used within the hydraulic model. These are tabulated and shown in Table 1 and Figure 2.

Table 1: River Great Ouse ReFH rainfall and peak flows

Return Period	DDF rainfall (mm)	Design rainfall (mm)	Peak rainfall (mm)	Peak runoff (m3/s)
2 year	29.8	19.7	2.1	8.3
10 years	45.6	30.9	3.3	12.7
20 years	55.3	36.6	3.9	14.6
30 years	61	40.4	4.3	15.8
50 years	69	45.7	4.9	17.6
100 years	81.4	54	5.8	20.3
1000 years	141	93.4	10	35.2

Figure 2: ReFH hydrographs



3.2.6 The 100 year flood, with allowance for climate change, was hence evaluated as 24.4m3/s

4 Baseline hydraulic modelling

4.1 Model definition

4.1.1 The hydraulic model was compiled to quantify the flood risk from the River Great Ouse at the location of the Proposed Scheme crossing.

4.2 Model build

4.2.1 A one-dimensional ISIS model was constructed using cross sectional information derived from the HS2 LiDAR data, with a resolution of $0.2m^2$. Twelve cross sections were extracted from the LiDAR and applied to the ISIS model.

4.2.2 Channel capacities were derived using the $0.2m^2$ LiDAR data. No detailed topographical survey was available to inform channel dimensions.

4.2.3 A Manning's n value of 0.040 was used to define the roughness values in the floodway (watercourse channel and floodplain) as derived from standard texts (Chow[1]).

4.2.4 The design inflows were applied using an ISIS ReFH unit at the upstream extent of model at the confluence of the discharge from the ponds near Illett's Farm.

4.2.5 A normal depth boundary was applied to the downstream extent of the model at Turweston Road, being automatically generated by ISIS based on a derived bedslope gradient of 1 in 200. The gradient was measured from thalweg of the derived cross sections.

4.3 Hydraulic constraints

4.3.1 The River Great Ouse bifurcates at the Proposed Scheme viaduct crossing. The western channel is known to convey the majority of flow. The eastern channel is perched and feeds Turweston Mill, located approximately 340m downstream of the crossing.

4.3.2 The bifurcation was represented as two channels in the same ISIS RIVER section. The LiDAR cross sections were of sufficient resolution for the purposes of the modelling to adequately define both channels.

4.3.3 Turweston Road represents a hydraulic constraint on the Great Ouse approximately 430m downstream of the Proposed Scheme viaduct crossing. This is outside the model extent and assumed to have no impact at the Proposed Scheme crossing.

4.3.4 No structures on either the Great Ouse or Turweston Mill stream were included in the baseline model.

4.4 Baseline model results

4.4.1 The ISIS hydraulic model was simulated to provide estimates of peak water level along the watercourse.

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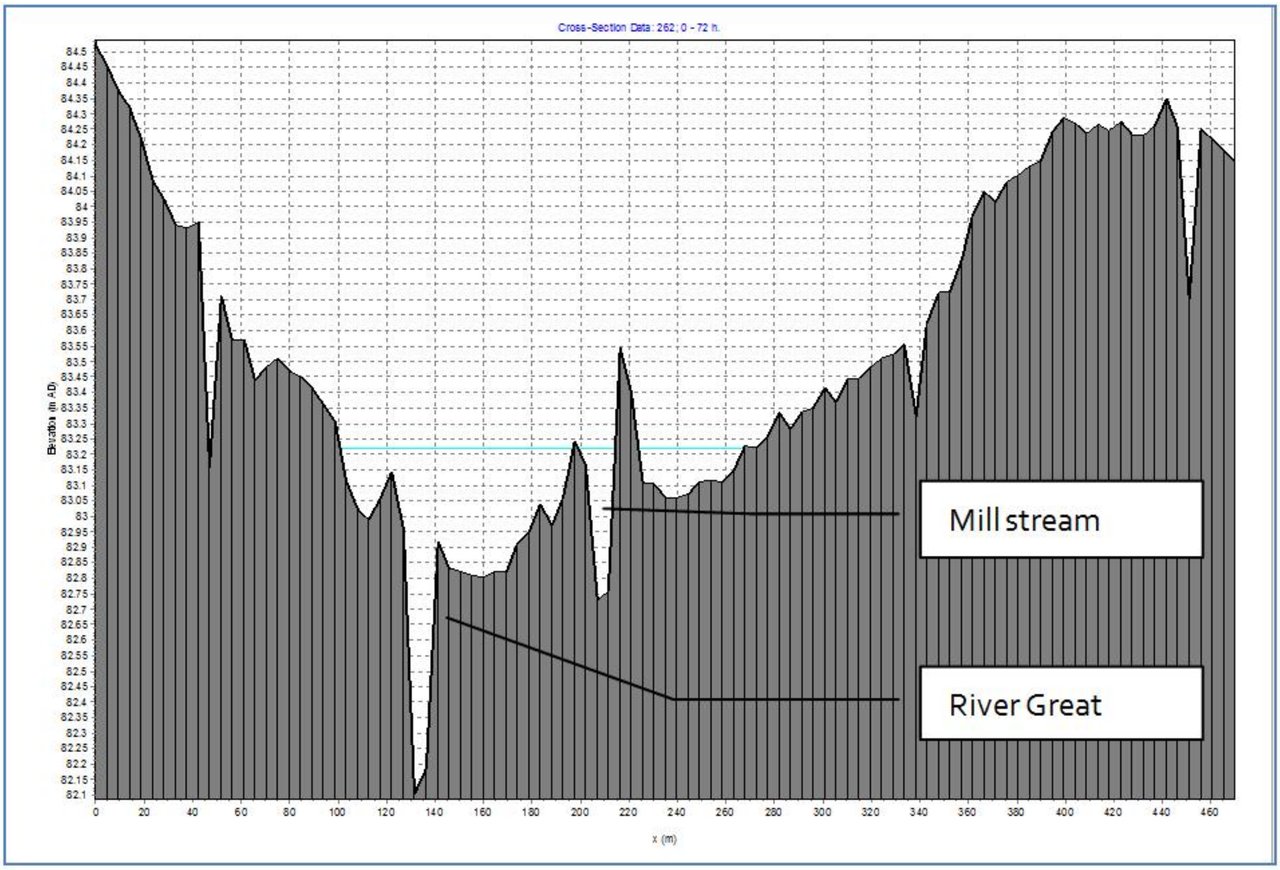
[1] Ven Te Chow (1959, 2009 edition). *Open-channel hydraulics*, The Blackburn Press, Caldwell, NJ, USA.

4.4.2 The mill stream is embanked on its eastern bank. This prevents water entering the floodplain until higher levels are reached – acting as an informal flood defence. The embankments were not modelled at this stage of the design process. Instead, the model represents peak flows along the floodway (channel and floodplain) to test the impact of the Proposed Scheme on flooding.

4.4.3 To that effect, the western bank embankment serves to limit flooding, and whilst the ISIS model does not simulate the temporal hydraulic behaviour during the whole event, it is appropriate for the peak.

4.4.4 A sample cross section from the model at the peak of the event at the location of the Proposed Scheme viaduct is shown below, with the 1 in 100 year plus climate change level shown. The proposed rail level is approximately 115.2m AOD at this location.

Figure 3: Cross Section showing Baseline Modelled Maximum Flood Levels



4.5 Validation

4.5.1 The predictions were compared with the Environment Agency floodplain mapping to provide confidence in the results. Flood levels were inferred from the Environment Agency mapping by deriving ground levels at the edge extents of the mapped floodplain.

4.5.2 Whilst not full calibration, this comparison does indicate whether the simple hydraulic model predicts appropriate water levels which correlate with other data sets.

4.5.3 A 1 in 100 year flood level of 105.64m AOD was inferred from the Environment Agency flood map. This compares with a prediction of 105.8m AOD at the same location from the ISIS model.

4.5.4 A 1 in 1000 year flood level of 105.88m AOD was inferred from the Environment Agency flood map. This compares with a prediction of 105.97m AOD at the same location from the ISIS model.

4.5.5 The validation implies that the ISIS model predicts peak flood levels that correlate well with the Environment Agency, although the model may overestimate flood risk.

4.6 Flood risk to Proposed Scheme

4.6.1 The main purpose of the modelling exercise was to more accurately define the flood risk to and from the Proposed Scheme.

Topography

4.6.2 The Proposed Scheme approaches the Great Ouse valley on embankment before crossing the floodway with a viaduct. The Proposed Scheme rail level here is approximately 115.2m AOD, carried by an earthwork embankment either side of the viaduct.

4.6.3 A narrow viaduct length of 50m was assessed in the modelling to provide a precautionary assessment of flood risk, when compared to a longer crossing.

Hydraulic Modelling

4.6.4 The proposed viaduct crossing was added to the model using a USBPR model unit. The viaduct soffit was assumed to be 110.50 AOD, with a minimum rail level of 115.2m AOD.

4.6.5 Ground levels across the relevant river sections were raised at the approaches to the viaduct to represent the rail embankments.

4.6.6 Viaduct piers were included using the PIER option within the ISIS model with a 4m wide pier.

Flood Levels

4.6.7 The peak flood levels quoted below were extracted from the one-dimensional model immediately at a distance 50m upstream of the proposed viaduct.

Table 2: Proposed scheme peak flood levels

	5% annual probability	1% annual probability	1% annual probability including allowance for climate change	0.1% annual probability
Baseline	105.76m AOD	105.85m AOD	105.91m AOD	106.03m AOD
Proposed Scheme	105.76m AOD	105.86m AOD	105.92m AOD	106.05m AOD
Maximum afflux	0mm	10mm	10mm	20mm
Maximum influence	50m upstream of the viaduct			

4.6.8 The floodplain width results shown in Table 3 are measured either side of the Proposed Scheme viaduct.

Table 3: Modelled floodplain widths

	Width		
Location	**20 Year**	**100 Year+CC**	**1000 Year**
Upstream of Proposed Scheme crossing	89m	98m	112m
Downstream of Proposed Scheme crossing	73m	101m	112m

Flow Velocities

4.6.9 Being a one-dimensional model flow velocities are given in the direction of flow only and averaged for each cross section.

4.6.10 As the river is embanked in this reach, a one-dimensional velocity is not representative of the true flow patterns. However, velocities vary between 0.26 – 0.63m/s.

5 Conclusions and recommendations

5.1 Conclusions

5.1.1 A flood flow for the Great Ouse was calculated using the UK standard ReFH approach. A 100 year flow of 20.3m3/s was derived.

5.1.2 A one-dimensional (ISIS) hydraulic model was developed using cross sections extracted from the HS2 LiDAR data.

5.1.3 Three flood events have been modelled; 20 year, 100 year with allowance for climate change and the 1000 year flood event.

5.1.4 For a 100 year flood event, including an allowance for climate change, the viaduct span of 50m increased peak water levels by 10mm. For the 1000 year flood event, the proposed crossing also increased peak water levels by only 20mm at the Proposed Scheme crossing.

6 Assumptions and Limitations

6.1 Summary

6.1.1 This section of the report lists the key assumptions and limitations of the hydrological calculations and hydraulic modelling carried out for this study.

6.1.2 Section 5.2 gives recommendations that could be carried out to improve the accuracy of the model.

6.1.3 The following points collate the key assumptions made and limitations of the current approach.

6.2 Hydrology

6.2.1 Flow estimation follows recommendations within the Flood Estimation Handbook in conjunction with the latest guidance on its use provided by the Environment Agency[2].

6.2.2 Catchment descriptors have been extracted from the FEH CD ROM v3 and sensibility checks have been undertaken. No Urban Expansion Factor[3] has been applied to URBEXT. The catchment AREA has been defined using the digital terrain model (DTM).

6.2.3 Only the ReFH method of flow estimation has been used and no comparison has been made with the EA grid-flow data, or any local river gauges. The critical storm duration has been calculated using the FEH equation[4].

6.2.4 Validation or calibration of the calculated flows with gauged records has not been carried out. Checks on the flood flow estimates are required using a more rigorous assessment with the full suite of FEH tools.

6.3 Use of Existing Data

6.3.1 No existing hydraulic or hydrological model is thought to be available.

6.3.2 Existing Environment Agency Flood Zone data has been used as a basis for comparison with modelled outputs. It is assumed this has been generated using JFLOW software.

6.4 Hydraulic Modelling

6.4.1 The representation of floodway is defined from the LiDAR DTM only using cross sections extracted at fixed locations.

6.4.2 Watercourse cross section profiles are based on LiDAR data only.

6.4.3 The alignment of the watercourse is based on the LiDAR data and the OS mapping.

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[2] Environment Agency (2012), *Flood Estimation Guidelines*, Version 4, 26/06/2012

[3] Bayliss, A.C. et al. March (2006), *URBEXT2000 – A new FEH catchment descriptor: Calculation, dissemination and application.* Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme, R&D Technical Report FD1919/TR. Defra, London.

[4] Houghton-Carr, H. (1999), *Flood Estimation Handbook – Volume4: Restatement and application of the Flood Studies Report rainfall-runoff method.* Institute of Hydrology, Wallingford.

6.4.4 Detailed survey of channel, floodplain and existing disused railway embankment is required to accurately model the floodway and evaluate the constriction caused by the existing and proposed structures. This will include specific cross sections.

6.4.5 No model schematisation has been made and parallel channels are represented within a single floodway. It is assumed that during flood, the whole valley operates to convey floodwater.

6.4.6 Hydraulic modelling of the parallel channels will be required to test impacts at all conditions through the full flow range. This will require schematisation of the model.

6.5 Model Parameters

6.5.1 Roughness of the study area has been defined using a single Manning's n value of 0.040.

6.5.2 The upstream and downstream model extents have been located a sufficient distance from the Proposed Scheme crossing to minimise any impact on model results.

6.5.3 Hydrological inflows have been applied in the model as a point inflow.

6.6 Structures

6.6.1 No site visits were undertaken as part of this study. The location and size of existing structures has been determined from OS Mapping and aerial photography only. Some small structures may well be omitted from the hydraulic model.

6.6.2 Detailed survey of structures was not obtained for this study. Structure dimensions have been derived from aerial photography and LiDAR data.

6.7 Proposed design scenarios

6.7.1 Modelling of the proposed viaduct crossings has focused on the earthwork embankments and abutments. The soffit level of the viaduct has been assumed to be sufficiently high so as not to be hydraulically significant but has been included within the USBPR unit. This includes all viaduct piers.

6.8 Post processing of results

6.8.1 The ISIS flood outlines presented have not undergone any post-processing, such as smoothing of edges or filling in of dry islands.

6.8.2 The methodology adopted in the processing of flood outlines for one-dimensional models may be different to that used in producing the outlines for the Environment Agency Flood Zone Maps. This may account for any discrepancies between the two outlines rather than indicate differences in the model results.

6.9 Validation

6.9.1 No sensitivity testing of model parameters (such as, but not limited to, roughness) has been carried out.

6.9.2 Comparisons have been made between the model results and the Environment Agency Flood Zone Maps. No other validation or calibration of the models has been carried out.

7 References

Bayliss, A.C. et al. March (2006), *URBEXT2000 – A new FEH catchment descriptor: Calculation, dissemination and application*. Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme, R&D Technical Report FD1919/TR. Defra, London.

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